Short note on Soil Science-IV

1. S-Oxidation in soils.

Ans: See "Sulphur" note.

2. K-fixation in soils.

Ans: K fixation does not occur to the same extent in all soils. It reaches its maximum, however in soils high in 2:1 clays with large amounts of illite. Fixation of K is the result of unavailability of K^+ ions between the layers of the 2:1 clays, the 1:1 types minerals such as kaolinite do not fix K. K ions are sufficient small to enter the silica sheets, where they are held very firmly by electrostatic forces.

K fixation is generally more important in fine textured soils which have a high fixation capacity for both K^+ and NH_4^+. K fixation capacity can be reduced by the presence of Al^{3+} and their polymers that form under acid condition.

From the fixation mechanism of both NH^{4+} and K^+ in soils it is found that these is an equilibrium between fixation and release. So fixation is not a entirely an irreversible phenomenon. Fixation and release can proceed simultaneously in a system containing heterogeneous minerals of 2:1 type not in equilibrium.

The release of fixed K^+ by montmorillonite and vermiculite is easier than that by illite.

Most of the K fixation adsorbed during drying of moist, high exchangeable K soils is associated with vermiculite as other minerals containing expanded Mica (Beidellite, illite).

Although the release of fixed K^+ is a very slow process. However, there are various factors to considered for the release of K^+ from micas by cation exchange.

3. Role of organic matter on soil fertility.

Ans: See "Organic manures and fertilizer" note.

5. Fertilizer Recommendations

The last phase in soil testing is making fertilizer recommendations. After calibration and interpretation, soil test data need to be associated with appropriate fertilizer rates. Each of the six common interpretative categories (very low, low, medium, optimum, high and very high) signifies different fertilizer rates. Only for high and moderate yield goals, fertilizer recommendations are suggested up to optimum level of soil test values for major nutrients. And for micro nutrient recommendations are suggested up to medium level of soil test values. No fertilizer recommendations is suggested when soil test values fall within high and very high categories. Moderate yield goals has been assumed to be around 80 % of the high yield goal. But for making fertilizer recommendations of moderate yield goals, about 80 % of high yield goal recommendations have been suggested.

In making fertilizer recommendations, not only for soil test but also climate, disease, insects, previous

crops, previous fertilizer application and soil yield potential should be considered. Maximum crop yield is obtained by fertilizer application, other cultural practices such as timely planting, adequate plant density, effective fertilizer application and efficient harvesting also contribute to increased yield. If a nutrient is mobile, as nitrogen is large amounts will be needed as potential yield increases.

Factors affecting fertilizer recommendations-

1. Soil
2. Crop and season.
3. Nutrient level.
4. Previous crop.
5. Desired yield.
6. Farmers ability for management.
7. Methods of fertilizer application.
8. Objective for production - Seed/ vegetative part/ export.

6. Contact exchange theory of plant nutrient uptake

Hence Genny and Overstreek (1938) found that there is a direct ionic exchange between the root cell and colloidal particle of soil. When the root hair cell and soil colloidal particles are in very intimate contact the cation of the soil colloid oscillate around their own axis and the same case of the Hydrogen ion of the root cell.

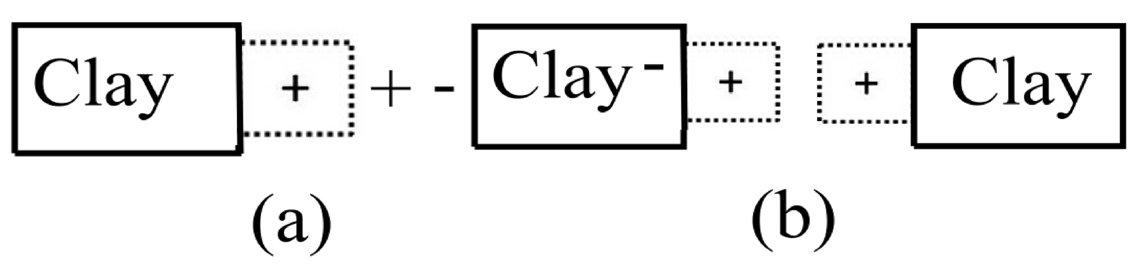

Fig: (a) Model of an ion exchange in soil solution.

(b) Model of a contact exchange between clay particles.

This dashed lines signify overlapping oscillation volumes.

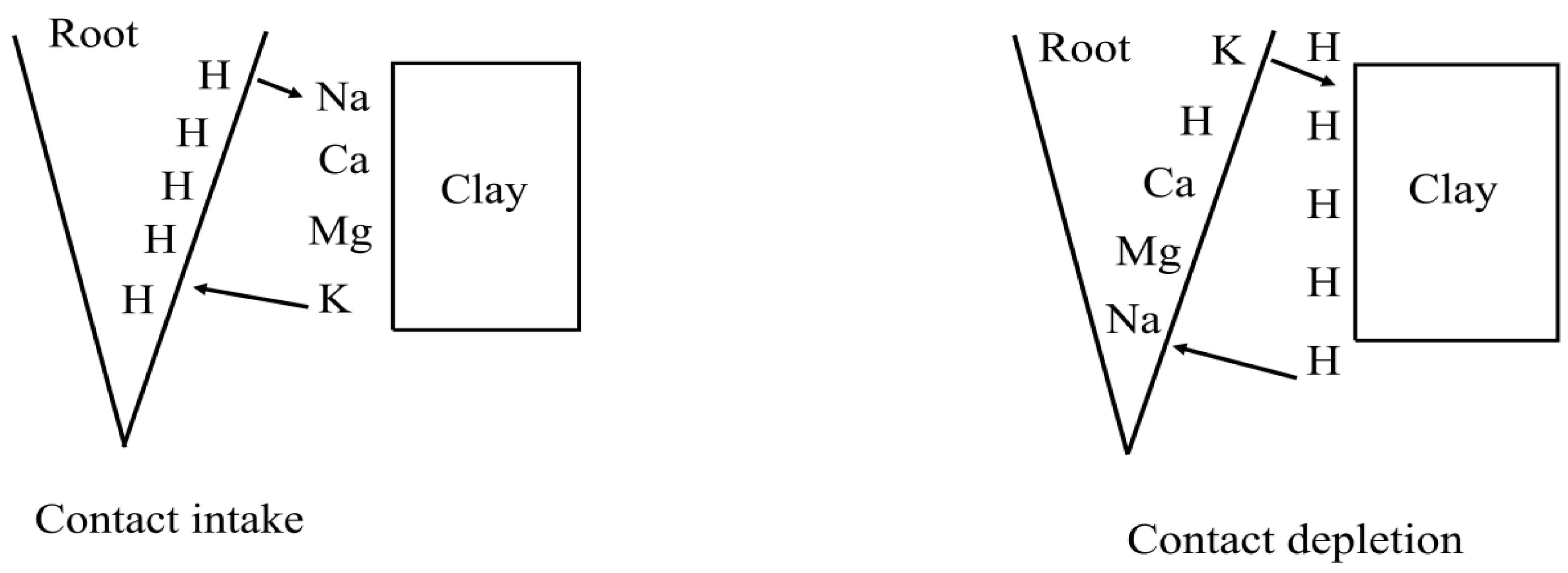

Fig: Schematic representation of contact intake and contact depletion of cations.

The oscillation volume of some of the cations of soil colloids would overlap those of some of the

$H^+$of the root cell. Under this condition there would be a direct ionic exchange of the root H^+ for soil colloidal cations. The process doesn't involve the soil water or the intermediate reaction of CO_2.

7. NH_3 Volatilization

Non-biological conversion of NH_4^+ to NO_3 is called volatilization. Volatilization occur under alkaline condition NH_4 is formed continuously in the soil & flood water through mineralization which under alkaline condition may be lost to the atmosphere as NH_3.

NH_3 volatilization loss occurs when NH_4 is present in a basic solution. Rice field are favourable for NH_3 volatilization because of submergence. The pH of most soil to converse near neutrality when the water pH rises above 7.4. NH_3 volatilization loses may be considerable.

It is now known that water pH values by mid day to values as high as pH 9.5-10 and decreases as much as 2-3 units during the nights upto above pH 9.

NH_3 concentration increases by a factor of 10 per unit increases of pH, NH_3 is unstable in H_2O and is evolved in increasing pH near and exceed 9. Lime content increases NH_3 volatilization. The greatest losses occur from surface application of urea fertilizer on calcareous soil.

Mechanism of Volatilization

When Containing or NH_4 forming -N- fertilizer are applied to a calcareous soil or to clay soil contains considerable amount of $CaCO_3$, the urease enzyme causes hydrolysis to form $(NH_4)_2CO_3$ as follows-

$$CO(NH_2)_2 + H_2O \xrightarrow[\text{Hydrolysis}]{\text{Urease}} (NH_4)_2CO_3$$

The $(NH_4)_2CO_3$ is unstable and quickly decomposed as follows-

$$(NH_4)_2CO_3 + H_2O \rightleftarrows 2NH_3 + H_2O + CO_2 \uparrow$$

In basic soils, $Ca(OH)_2$ may react with $(NH_4)_2CO_3$ to form NH_4OH. The NH_4OH easily decomposes to NH_3 and H_2O.

$$(NH_4)CO_3 + Ca(OH)_2 \rightarrow 2NH_4OH + CaCO_3 \text{ (precipitate)}$$

$$NH_4OH \rightarrow \uparrow NH_3 + H_2O$$

In general, two reactions occur when NH_4^+ is added to a calcareous soil.

$$(NH_4)_2Y + CaCO_3 \rightarrow (NH_4)_2CO_3 + Ca\ Y.$$

$$(NH_4)CO_3 + H_2O \rightarrow \underbrace{2NH_3 + 2H_2O}_{2NH_4OH} + CO_2$$

If the Ca Y salt is insoluble, the NH_3 loss is greatest.

When $(NH_4)CO_3$ decomposes, CO_2 is lost faster rate than NH_3 thereby producing OH^- ions and increase in $[(OH^-)]$. More solution NH_4^+ ion become electrically balanced by OH^- ions, which could favour loss as represented by the following reaction-

$$NH_4^+ + OH^- \rightleftarrows NH_4OH \rightleftarrows NH_3 + H_2O$$

$$[CO(NH_2)_2 + H_2O \xrightarrow[\text{Hydrolysis}]{\text{Urease}} 2NH_3 + H_2O + CO_2 \uparrow$$

$$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$$

$$NH_4^+ + OH^- \rightleftarrows NH_4OH \rightleftarrows NH_3 + H_2O\ ]$$

Even application of $(NH_4)_2SO_4$ to calcareous soil causes NH_4 to volatilization losses as follows

$$(NH_4)_2SO_4 + CaCO_3 \rightarrow 2NH_3 + CO_2 \uparrow + H_2O + CaSO_4$$